Ultra-Flat Antennas for Space Applications: Design, Realization and Measurements

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In the last decade, the attention of the scientific community for the development of new classes of materials displaying non natural macroscopic properties has noticeably grown. Engineered materials whose properties can be artificially controlled and tailored, also known as Metamaterials (MTMs), have found application in a large number of new devices or have been applied in existing ones. Metamaterials consist of homogeneous environments filled up with engineered sub-wavelength particles which can vary in size and shapes according to the frequency domain. Disposition and particle features are chosen in order to precisely tailor the desired medium behavior. This typology of structures has found application in several research fields including Microwaves, Optics and Electromagnetics. Development of new kind of lenses, resonators, double negative index materials is an example.

Among MTMs an extremely interesting sub-class is constituted by Metasurfaces (MTSs) which benefit of lower losses, lower bulkiness and profile and accurate control of the sustained electromagnetic field. Recent advances in circuit printing technology have also rendered MTS solutions extremely cost effective options for antenna design and very appealing for several practical applications. Over the many examples present in literature MTSs have been successfully employed for implementing equivalent variable boundary conditions which are suitable to transform a guided wave into a radiative leaky-wave for antenna applications. This concept has been introduced in the '50s by Oliner and Hessel and more recently further developments to their seminal work have been laid down. The possibility to analyze and implement anisotropic impedance planes has allowed the management polarization issues in ultra-flat antennas by effectively acting on the anisotropic impedance modulation.

The purpose of this paper is to present two low-cost, low-mass, low-envelope and high gain antenna prototypes developed in the framework of the European Space Agency projects for deep-space missions. The prototypes operate in X-band at center frequencies of 7.165GHz and 8.425GHz with radii of 3.58λ and 7.58λ respectively; they produce a circularly polarized broadside pencil beam showing, for the bigger aperture, a gain performance of 28.2dBi and cross-polar discrimination of around 17dBi. Theory and practical aspects concerning analysis and design steps for accurate control of the phase and tapering of the aperture field, as well as measurements for the proposed antenna prototypes will be presented at the Conference.